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On Mechanism, Process and Polity: An Agent-Based Modeling and Simulation Approach[1]

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Abstract

The present approach provides a theoretical account of political culture-based modeling of political change phenomena. Our approach is an agent-based simulation model inspired by a social-psychological account of the relation between the individual agents (citizens) and the polity. It includes political culture as a fundamental modeling dimension. On this background, we reconsider the operational definitions of *agent, mechanism, process,* and *polity* so as to specify the role they play in the modeling of political change phenomena. We evaluate our previous experimental simulation experience in corruption emergence and political attitude change. The paper approaches the *artificial polity* as a political culture-based model of a body politic. It involves political culture concepts to account for the complexity of domestic political phenomena, going from political attitude change at the individual level up to major political change at the societal level. Architecture, structure, unit of interaction, generative mechanisms and processes are described. Both conceptual and experimental issues are described so as to highlight the differences between the simulation models of society and polity.

Keywords: political change, political culture-based modeling, artificial polity, simulation modeling

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Motto:
"But there is more to social mechanisms than just individual interactions…"[2]

1. Introduction

Social modeling is understood as a complex way of explaining social phenomena. It has been successfully used in Social Simulation as a way of explaining social action and emergent phenomena. With just a step behind, Political Methodology has included simulation modeling only recently and only in some areas of simulation modeling research, International Relations and Voting Behavior being the most preferred research areas for their rather easy appropriation of agent-based system models.

In Agent-Based Modeling (ABM), the concepts of *artificial society* and *artificial polity* share the notions of "agent" and "individual agency", and also the methodological individualism approach on social action modeling. The *artificial society* is a bottom-up model which addresses the micro-macro link in explaining emergent social phenomena (Squazzoni, 2008), where by "emergence" we take as a basis the view proposed by agent-based system modelers of the social phenomena as macro (high-level) effect of the micro (low-level) interactions (Axelrod 1997, p.4; Epstein and Axtell 1996, p.35), which are not deducible from the laws characterizing the lower-level domain phenomena ("strong emergence", Chalmers, 2006).

Polity simulation modeling research has intensively used agent-based models, like *Sugarscape* (Epstein and Axtell, 1996; Epstein, 2002) in order to get bottom-up models of political violence, explaining it therefore as emergent macro-scale social phenomena rooted in the micro-dynamics of the interactions between individual agents (Cioffi-Revilla and Rouleau, 2010, p. 34). This has led researchers of emergent political phenomena to concentrate more on the micro-to-macro link so as to show how the dynamics of micro-level individual interactions could impact the stability of the state. Such polity models like *GeoSim* (Cederman, 2003b), *RebeLand* (Cioffi-Revilla and Rouleau, 2009), *REsCape* (Bhavnani et al., 2008) address the relation between the individual agents and the state as a means to study the polity's response to variability in the individual interactions at the micro level.

From a general methodological perspective, polity simulation modeling research has been mainly concerned with macro-level agents ("states") modeled as individual agents. Some of these approaches focus on the individual citizen as the typical agent, of which the *ReBeLand* Model (Cioffi-Revilla and Rouleau, 2009; 2010) is considered to be representative. It includes a culturalist approach of the origins of political instability by modeling the ethnical conflicts as a source of political violence. However, the debates on the appropriateness of the culturalist aspects in this and in other similar models like Cederman and Girardin's model of ethnicity and nationalist insurgency (Cederman and Girardin, 2007, 2010), have weakened the political culture hypothesis so as to leave this modeling dimension open to further debate.

Explaining these differences is important for both theoretical and experimental modeling purposes. Our modeling approach of polity is meant to address the "downward causation" effect (macro-micro link) by including political culture as a modeling dimension aimed at explaining the role political culture theory might play in the modeling and simulation of both society and polity.

[2] Steel D. (2004) Social Mechanisms and Causal Inference, *Philosophy of the Social Sciences*, No. 34, p.58.

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2. The Modeling Approach

The present paper combines *political culture modeling* with the simulation of *artificial society* and *artificial polity* in a complex account on political change phenomena. The approach reported in this paper builds upon the computational and simulation modeling experiments which have been developed during the past years (Voinea, 2012, 2013). These experiments are aimed at computationally modeling and simulating the Eastern European political phenomena after the Fall of Berlin Wall. Our model employs elements of political culture theory in order to provide for a political culture-based modeling approach of political change. It addresses the fundamental concepts of 'political mechanism', 'process', 'modeling' and 'explanation'.

2.1 Justification of Approach

Our approach is inspired by a social-psychological account of the relation between the individual agent (micro-level) and the polity (macro-level) and includes political culture as a fundamental modeling dimension. On this background, we reconsider agent's, mechanism's, process's, and polity's theoretical and operational definitions so as to specify the role they play in the modeling of political change phenomena. We have therefore proceeded to evaluate our previous experimental simulation experience in order to get the necessary background for a correct understanding of the nature and type of theoretical issues hidden in rich experimental clues.

The paper approaches the *artificial polity* as a political culture-based model of a body politic. It involves political culture concepts and theories to account for the complexity of domestic political phenomena, going from political attitude change at the individual level up to major political change at the societal level. Architecture, structure, unit of interaction, generative mechanisms and processes are but few of the modeling dimensions manifold. Both conceptual and experimental issues are described so as to highlight the differences between the simulation models of society and polity.

This approach addresses in general lines fundamental problems of society and polity simulation modeling and, obviously, does not provide answers to all theoretical questions. However, it stands for one more step towards finding the proper answer to an old fundamental requirement formulated by Charles Tilly in 1995 with concern to the way in which political processes are explained. Computational and simulation modeling scientists should perhaps pay particular attention to the requirements of political scientists and to their often discouraging skepticism with concern to the newly developed simulation modeling methods, no matter how revolutionary these might be: what they ask for is not always what they get from us. Looking for the proper answer to their requirements, challenging their skepticism, and paraphrasing Tilly, we could ask ourselves: "*how, then, should we search for the causes of revolutions?"* (Tilly, 1995, p. 1602).

2.2 Aims of Approach

In the present approach, we aim at modeling what some authors call "situational context" (Hedström and Swedberg, 1998) or "downward causation" (Sawyer, 2002), namely the macro-level and the macro-to-micro phenomena.

From a theoretical point of view, our approach combines both *collectivist* and *individualist* tenets into an unifying view much inspired by the neo-cultural synthesis proposed by Mishker and Pollack (2003). The fundamental dimension of our approach is therefore the political culture and the role it plays in explaining and making effective the macro-to-micro link. Based on our artificial polity experimental research work, we aim to prove effective the four types of downward causation defined by Sawyer (2002, p. 217).

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One os the previous theoretical and experimental reseach approaches, *Briberyscape* (Voinea, 2012, 2013), models corruption as a micro-to-macro emergent phenomenon in an authoritarian regime. It exhibits downward causation effects by increasingly getting the political macro structures (the state) constraining the patterns of individual interactions among citizens and among citizens and institutions. Other two models, *Privilegescape* ("Privilege Market" Model) and *Baronscape* (Local Patron-Client Networking Model) model the macro emergence of specific political phenomena characterizing the failure from inside of an authoritarian regime: one such phenomenon was the emergence of autonomous networks of trust which parallel and weaken the network of trust in state. In these models, the downward causation concerns macro structures (relatively stable emergents) which constrain the individual interactions, like the networks of trust.

Our simulation model uses both mechanisms and processes as generative engines, combining *substantialist* with *relationist* concepts of the generative theory of political interaction. The main differences from other approaches on polity simulation models concern (1) the *type* and *domain* of studied political phenomena, (2) the type of *generative architecture* and (3) the types of objects and/or processes which are considered as *generative engines* in the hypothesized scenarios of political change.

The *type* of political phenomena considered is the political change phenomena, and the *domain* of study is the political change in domestic politics, as a difference from approaches concerning political change in International Relations (Axelrod, 1995; Cederman, 1997, 2003b; Cioffi-Revilla, 2010b). We are mainly concerned with the transition-to-democracy political phenomena and, in particular, with political change phenomena in the Eastern European communist and post-communist regimes. As a difference from other simulation modeling approaches, ours models the *polity* by involving the political culture as a key component in describing the political change.

As it regards the type of generative *architecture* of the simulation model, our approach is based on the concepts of generative political mechanism and process, and includes social action issues (individual interactions), polity issues (power, inequality, coercion and institutions), and political culture issues (attitudes, beliefs, values, and norms).

As a metodologic background, our approach starts from the social simulation prototype model: the artificial society described by the Sugarscape Model developed by Epstein and Axtell (1996). Our approach modifies this basic simulation model as to achieve an explanation of the macro-level and macro-to-micro phenomena and of their impact onto the behavior of the individual agents. In order to achieve this goal, the proposed simulation model introduces three levels of *generative engines* (generative objects and processes): social, political, and culture objects and relations. The idea of using political culture objects (beliefs, values, norms and attitudes) and their generative ontologies is aimed at proving that political culture objects and processes could and should be used as both generative and control engines with regard to the proper workings of a polity.

2.3 What Is Our Approach Arguing For?

Our approach constructs arguments concerning mainly three operational issues. The first issue suggests that political culture is a multi-layer operational model: layers of recurrent political processses which make up the macro operational level, and layers of generative mechanisms and processes which make up the micro operational level. The second issue suggests that the generative multi-layer architecture should combine the political action and structure modeling paradigms of "methodological individualism" and "relationism" so as to allow for both micro-to-macro and macro-to-micro explanations. The third issue concerns the political culture modeling paradigm, and suggests that "thick-and-thin" continua could be identified in social, political and culture phenomena.

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We argue in the first place that modeling as explanation of political change phenomena cannot exclude political culture as both change generative and change control 'engine'. As an alternative to the "*figurations*" introduced by Norbert Elias (1978, 1982) and the topological "*configurations*" described by Cederman (2003a), we suggest a new taxonomy of configurations: *political cultural configurations*, which include attitudes, beliefs, values, and norms configurations. Secondly, we argue that modeling of political phenomena should be based on generative operational concepts, like generative processes and geenrative mechanisms.

Generative modeling in social science is based on mechanisms which generate social structure by means of individual interactions (methodological individualism). The original model of the artificial society (*sugarscape*) provides for a bottom-up account on the emergent social outcomes of micro-level individual interactions. Simple as idea and efficient as architecture (two-layer architecture), the artificial society model is interesting for its methodological individualism and for introducing the concept of generative mechanism as a basic 'engine' of the social action. The model cannot however provide any account on the macro-to-micro social phenomena, nor does it use a (political) culture model[3]. Hedström and Swedberg (1998) have introduced the notion of "*structural individualism*", which represents an advanced version of methodological individualism able to provide for an explanation of the macro-to-micro phenomena.

We start from this idea and describe a class of experimental simulation models of (i) change in the attitude toward the state, and (ii) change of the trust in the state in both communist and post-communist Eastern European polity inspired by the political qualitative and empirical models elaborated after 1989 (Tilly, 2000; Whitefield, 2005; Kubik, 1994, 2012; Mishler and Pollack, 2003; Pickel and Pollack, 2013; Wildavaski, 1987; Diamond, 1998; Inglehart, 1992, 2000; Inglehart & Welzel, 2005; Rohrschneider, 2002, 2006; Sztompka 1993a, 1993b).

On the basis of this class of simulation models, we argue that political culture mechanisms and processes provide support for-, and are able to explain the idea of downward causation, by identifying the kind of influence the macro phenomena have on the micro-level behavior of the individual agents.

3. A Political Culture-Based Simulation Modeling of Polity

3.1 The Fall of Berlin Wall: Eastern European Political Change Phenomena

Eastern European political regime changes initiated in 1989 provided shortly afterwards a particular impetus for a revived interest in political culture studies. Notwithstanding the major differences in the conceptual paradigms of the various schools of thought, and the hardness of the critical views with respect to their explanative power, these studies shed light on several issues addressing political culture modeling propensities. Though not surprising, since revived interest in political culture theories seems to have been re-iterated by major crises and/or political changes all over the world (Elkins and Simeon, 1979; Inglehart, 1988), the post-1989 revival has been especially relevant for at least one reason: old and new political culture theories "clashed" on the atypical analysis field of the Eastern European post-communist political regimes. One particular outcome of this after-1989 clash is considered one of the most challenging political culture theories: Mishler and Pollack's "Thick-and-Thin" Neo-Cultural Synthesis (Mishler and Pollack, 2003).

Political Culture studies and analyses of the Eastern European political phenomena after the Fall of Berlin Wall put a special emphasis on the need to develop models of the complex processes of transition to

[3] Epstein and Axtell developed several research experiments on conflict resolution in terms of international relations and state agents. However, these researches cannot provide for a political culture model.

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democracy, democratization, and democracy consolidation in post-communist political regimes (Mishler and Pollack, 2003; Whitefield, 2005).

3.2 Old and New in Political Culture Modeling

Explanative by their definition and concept, *models* have been understood as abstract constructions which best capture the causality issue in context-dependent political phenomena (Merton, 1948, 1957). In Political Analysis, as an area of research in which traditional empirical-based analysis is still the dominating paradigm, the undeniable need for models has constantly moved things forward, even if not always fast enough for the expectations of the political scientists. From the times of the "*The Civic Culture*" (Almond and Verba, 1963) and its "clash" with the alternative theory elaborated by Lijphart (1968), the need for political culture-based models of political phenomena has increasingly fueled the controversies over their explanative power, and has penetrated the epistemology of the domain, shaping the demand for a consistent methodological change (Eckstein, 1988, p.790) from model-invariant to context-based modeling paradigms. In spite of their long-standing principles, their clear dominance and stability in the domain's research methodology, and the substance and accuracy of their analytical achievements, the deductive-nomological explanations and their associated modeling theories (Hempel, 1965) have increasingly been subjected to critical evaluations and disputes during the past decades.

Completely different from the empirical modeling theories, newly emerging computational and simulation modeling technologies have definitely contributed to the decline of the model-invariant explanative theories and to the methodological shift towards generative mechanisms, bottom-up models, and virtual experiment techniques. Undoubtedly, this methodological change has been claimed long before political science scholars, like Charles Tilly (to take but one example), have started to criticize the inability of model-invariant methodology to capture the variability and contextual dependences of the major political change phenomena. The way from the genuine demand for change up to the proper methodological change has often seemed to get stuck in kind of difficult-to-cross borderline between different epistemological constructions on what a model *could* and *should* explain in political culture theories.

Computational and simulation models in social sciences have inspired much of the research work which has been lately developed in Computational Political Science, in mainly two areas: International Relations, and Voting Vehavior. Social Simulation, Computational Sociology, Complex Adaptive Systems, and Agent-Based Modeling Systems have provided the background concepts and techniques used now largely in Political Methodology in these areas of the simulation modeling research. Theoretical and formal social action models, for instance, which have inspired the well-known artificial society model (Epstein and Axtell, 1996), have provided the dominating modeling theory, concept and paradigm in the International Relations area of research. Political Methodology, traditionally based on empirical research and statistical tools of analysis, has increasingly showed a clear tendency in the direction of identifying specific tools and evaluation frameworks which could provide for a different and more believable approach on issues like context-, path-, and initial conditions-dependency of political phenomena. Not only the practitioners, but the theorists themselves (Tilly 1995, 2000, 2001), have given strong support to the claim for a radical change in the political methodological research paradigms, which should approach political phenomena in their real complexity. The interest on the complexity of phenomena has been transferred rather quickly on the complexity of methodology, so that individual agent, social interaction, emergent social phenomena, and society could thus be considered dimensions in this methodological shift.

Both computational and simulation modeling have brought from Social Simulation the basic concepts and paradigms which have assisted Computational Political Science to emerge and grow-up as a new discipline. Unavoidable though, controversies on both epistemological and ontological aspects in the

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Social Simulation theories have extended their reach to the political modeling research, which has lately included both agent-based and complex adaptive modeling techniques.

Political culture models on the one hand (Inglehart, 1990; Putnam, 1993; Eckstein, 1988; Diamond, 1998), and Social Simulation modeling theories (Axelrod, 1995; Gilbert and Troitzsch, 2005; Macy and Willer, 2002; Squazzoni, 2012) on the other hand, have been so hardly disputed as to make this methodological shift even harder. Nonetheless, political culture theories have endured and "… *not only survived but mounted an impressive comeback over the past decade*...." (Mishler and Pollack, 2003). The question now is what their impact actually is on the massive modeling re-shaping attempts supported by the newly developed social simulation and artificial society technologies? – As a matter of fact, this question is just a re-iteration of both Tilly's famous request and Mishler and Pollack's claim for renewing the political phenomena modeling methodology.

3.3 On Modeling "Thick-and-Thin" in Eastern European Political Culture

Natural and undoubtedly justified as it is, modeling is the missing part of this "*impressive comeback*" of political culture theories. Moreover, if there is a point of convergence of various types of skepticism and denial with respect to the explanative power of political culture modeling, than this has to be the simulation modeling. It is *this* particular weakness, *this* particular skepticism, and *this* particular convergence point of denial positions with respect to political culture-based modeling that we are going to tackle in this approach.

With their neo-cultural synthesis, Mishler and Pollack (*ibid*.) have actually threw the glove to all modelers of political culture, political and social scientists as well. Notwithstanding its strength, their challenge has left some category of scientists untouched: the computational and simulation modelers. The reason?

To the satisfaction of those who have given support to the classical so-called "thick" theories and who hang on empirical data and statistical analysis, and to the disappointment of those who have given support to the so-called "thin" theories and who might expect something different then just survey stuff, in spite of Mishler and Pollack's own claim for a unifying, synthetical approach, their political neo-culture synthetic model (*ibid.*, p. 247) is just a common analytical model. Though extremely challenging in theory, their neo-cultural synthetic model itself is deeply rooted in the empirical analytical tradition.

Explaining what is disappointing in it would actually offer the chance to make a description and analysis of the modeling approach in the present paper.

3.4 Explanative Power of Political Culture Models

The debates on political culture addressing its explanative power are mainly based on the controversies concerning the definition of culture as either a "property of colectivity" or as a property of the individual agent (Elkins and Simeon, 1979, p.129) emphasizing both a theoretical and a methodological ambiguity characterizing distinct schools of thought. The controversy comes from the different theoretical backgrounds: while the former is insired by anthropologist and sociologic theories, the latter is of social-psychology inspiration. Advocates of the collectivity alternative as Bourdieu (1972), Geertz (1973a; 1973b), Inglehart (1990), Putnam (1993), or Huntington (1996), inspired by Tylor's classical definition of culture (1871), are more concerned with anthropological and sociological perspectives on culture. A second school of thought advocates an individual-based view of culture, like Conover and Searing (1994), Norander and Jones (1996), McFalls (2001), who are generally inspired by classical works of Almond and Verba (1965) and Converse (1964), emphasizing concern with social-psychological perspective on culture.

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Conceptual controversies based on the dichotomy between ideatic (idealist) and economic (materialist) views of culture have generated also methodological controversies mainly focused on the methods of measurement and collection of empirical data. As much as the conceptual ones, the methodological disputes are opposing different views on the modeling methodologies.

Mishler and Pollack's neo-cultural syhthesis (2003) challenges both the collectivity-based, and the individual-based approaches by mixing them up in a continuum of the cultural agency concept. Among the seven dimensions on which (political) culture is "poorly explicated" (Reisinger, 1995), the interaction between culture and polity highlights the instrumental role culture plays in the emergence and dynamics of political phenomena. Culture as a "control mechanism" (Geertz, 1973a, p.87; Elkins and Simeon, 1979, p.129) concerns a societal perspective on how culture is defined.

We base our approach on Mishler and Pollack's definition of political culture (2003) as the conceptual support of a strategy of explanation based on an unifying paradigm of both micro-to-macro and macro-to-micro explanatory components of the political change phenomena. The political culture concept defined by Mishler and Pollack (*ibid*.) brings to the forefront an unusual idea for the traditional definitional approaches on political culture: the 'continuum'. Their "thick-and-thin" definition uncovers several epistemological hypotheses which have been (and still are!) opposed by different schools of thought on what has been too much disputed a concept in both social and political sciences during the past half of century European intellectual history. In their article, published in one of the best approaches to Eastern European post-communist transition to democracy, "*Political Culture in Post-communist Europe: Attitudes in New Democracies" (*D. Pollack, J. Jacobs, O. Muller and G. Pickel (Eds.), 2003), Mishler and Pollack argue for a neo-cultural synthesis which could explain the complexity of the attitudes toward democracy of the people in countries which have experienced authoritarian regimes and which undergo major political regime change processes. Their approach brings to the front the need for models able to provide explanations of both past and present phenomena unfolding in Eastern European polities and politics.

Though often subject to intense conceptual debate in both social and political science, we argue that the issue of explanation in polity modeling should be approached from a political culture-based perspective. Causal models of explanations have been mainly elaborated in social theory with little or no cultural explanative factors. The new emphasis on culture theories, and on political culture in particular, has emerged from both the study of social and political evidence and from the need to uncover the deep complexity of major political change phenomena.

Mainstream political theory and modeling methodology is deeply anchored in the Humean inspired deductive-nomological framework of causation and explanation as it has been theoretized by Carl Hempel (1965). Nomothetic modeling is always in search for the so-called 'covering-laws', i.e. universal laws able to explain political phenomena no matter the spatio-temporal conditions and characteristics of their development (Bennet, 2003). Though extremely powerful at the level of global or universal regularities (patterns) extracted by comparative analysis from huge amounts of empirical data, the nomothetic models fail to capture the variability and context-dependency of political phenomena. This methodological weakness induces a more subtle one at the conceptual level, since nomothetic modeling does not base causation in the variability of phenomena, and hence cannot explain it. The complexity of political phenomena made the model-invariant explanative solutions often inadequate.

The mainstream political modeling methodology has been challenged during the past decades by a powerful alternative, namely the *generative theory*.

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3.5 Generative Theories of Social and Political Action

Starting with Thomas Schelling's dynamic model of segregation (1971), the generative theory of social action covers both mechanism-based and process-based modeling approaches on social interaction. Mechanism-based modeling of social action is mainly concerned with the explanation of micro-macro phenomena described in the well-known Coleman's model of social action (Coleman, 1986). The strength of Coleman's model resides in its capacity to explain the micro-level and the micro-to-macro emergent social phenomena. In this model of social action, mechanism-based modeling's explanative power is limited to the micro-macro link (Sawyer, 2005; McAdam, Tarrow and Tilly, 2008).

"Downward causation" is a term used in the emergence theory to describe the influence the macro level phenomena might have on the micro-level phenomena (Sawyer, 2005; pp.69-73). It has been the subjet of epistemological disputes over the existence of the emergent structures at the macro level and of their impact on the individual level of social interaction. Mechanism-based versions of generative theory cannot however explain macro-level, and macro-to-micro phenomena.

Process-based modeling is usually connected to the sociological process theory. While mechanism-based theories have been mainly employed to explain micro-to-macro emergent social structure, the process-based modeling has been used by the generative theory in what regards the explanation of macro phenomena. It has inspired two schools of thought: *substantialist* and *relationist* (Emirbayer, 1997). The substantialist paradigm starts from individual actors and society as ultimate generative social units, and works with ontologies of objects which are involved in dynamical processes of interaction. The relationist paradigm starts from the relations between social units as the true dynamical generative processes (Emirbayer, 1997; Cederman, 2003a).

One of the breakthroughs in the theories on political mechanisms was the concept of *relational mechanism* as a generative engine in scenarios of political change (McAdam, Tarrow and Tilly, 2008). It combines, at least in theory, the idea of object (individual actor) as generative mechanism with the idea of process as a generative "engine" in the study of political phenomena. This combination has actually represented the answer to an earlier request made by Charles Tilly during the mid'90s with concern to the need for new causal and explanative paradigms in political methodology. In spite of considerable development of computational and simulation modeling theories and technologies, Tilly has re-iterated his demand several times over a periode of fifteen years (1995, 2001, 2008).

Though there is a rich literature on epistemic and ontologic aspects of the political mechanism issue, the answer to Tilly's 1995-claim has been provided by the computational modeling theories in social simulation by means of the generative techniques. They mainly refer to agent-based simulation modeling techniques. However, Tilly's request has not received so far a complete answer. He provides very interesting collections of empirical descriptions on political phenomena, mechanisms and processes which have not been addressed or used so far by the contemporary generative modeling theories. His examples have not been re-constructed on a generative modeling basis, though many authors admit the limitations of current models (Sawyer, 2004a, 2004b) and the need for enhanced process description and representation tehniques (Fararo, 1989). There still is a considerable need for modeling in the area.

4. Model Architecture

Our present approach models both the society and the polity as different layers of the overall architecture of the simulation model. The operational architecture used in our approach is depicted in **Figure 1.**

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We introduce the idea that an agent-based simulation system is a multi-layered structure, by "layer" denoting a certain level of activity pattern characterized by a specific degree of complexity, namely: (1) the micro and macro layers, where the agents interact and their dynamic interaction patterns evolve in either directly observable or implicit frames, (2) the micro-to-micro and macro-to-macro layers, where the relations between agents emerge from their interactions and the dynamic relational patterns are described as interconnection processes, and (3) the micro-to-macro and macro-to-micro layers, where the political culture agents (values, beliefs, norms, attitudes) and their dynamic change patterns are described as upward and downward control processes. The advantage of this multi-layer structural architecture is that it provides the operational framework in which the macro-to-micro and macro-to-macro phenomena can be described.

First, the generative mechanism-and-processes architecture is defined, described and explained as a multi-layer architecture, in which each layer is characterized by the same processing principle and structure. As explained in the preliminary sections of this paper, the *artificial society* model uses a two-layered architecture of generative mechanisms: the basic layer is that of biological inspired mechanisms, like hunger, motion, reproduction; the second layer is that of socially inspired mechanisms, like interaction among the individual agents. We modify this model. Our model aims at further developing this type of architecture by including three layers: the basic layer is that of survival mechanisms, the second layer is that of social mechanisms, and the third layer is that of cultural mechanisms. This three-layer architecture might be scaled-up at a multi-layer architecture in which several types of generative mechanisms and processes are included in each layer.

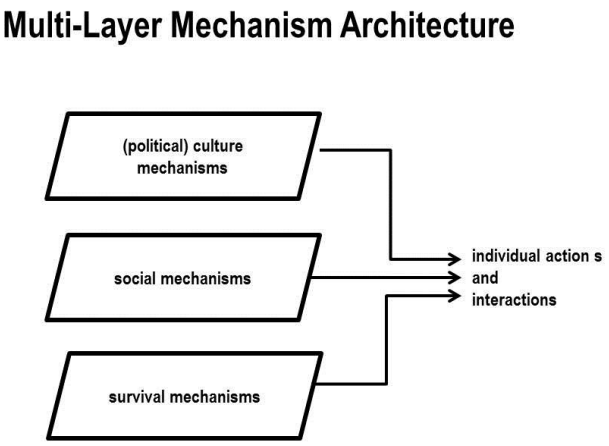

Figure 1.
Abstract operational architecture.

Second, the structure consists in (a) mechanisms, which are responsible for triggering and maintaining (b) the (network of) generative processes. Both the mechanisms and the processes are classified as (i) generative, and (ii) control. The generative mechanisms are basically social interaction mechanisms. In our approach, the generative mechanisms include environmental and culture mechanisms.

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Third, the control mechanisms are basically culture mechanisms: they consists in a structure of dynamically evolving culture processes defining values, beliefs, norms and attitudes. They evolve interdependently, influencing each other and finally producing a cultural context.

This simulation model based on a generalized generative architecture is used to grow-up an *artificial polity*. It represents the experimental setup in which several political phenomena, like the emergence of networks of trust and the emergence of corruption, are simulated (Voinea, 2012, 2013).

4.1 Mechanisms

The concept of *political mechanism* has been the subject of intense theoretical debates during the past decades. Debates covered the theoretical definitions of political mechanism and focused on the comparative analysis with classical nomothetic models (Tilly, 1995, 2000, 2001; Bunge, 1997). The controversies over the nature of mechanisms and causal models start from the definitions of mechanisms and causal modeling of social phenomena[4]. The interest in political mechanisms and causal models has been justified and sustained by several theorists and philosophers in social sciences. The need for explanation with concern to major social phenomena has resulted in the mechanism-explanation model theories (Merton, 1948; Tilly, 1995; Bunge, 1997; Elster, 1998; Hedström and Swedberg, 1998). With the advance of Social Simulation, this debate extended to computational and simulation modeling research with the aim of developing techniques and methodologies able to replicate real political mechanisms and provide for explanative computational and simulation models of political phenomena (Cederman, 2003).

While some authors are advocating a logical-based approach to mechanism (Tilly, 1995), others are advocating a methodological individualist approach, mainly promoted by the school of Analytical Sociology (Hedström and Swedberg, 1998). The latter is close to the idea of mechanism used in Social Simulation. Both of them consider the agents as separate "entities", and the overall variation of the system as "activity", including both the interactions and the processes they generate and maintain. Though the mechanisms are defined in terms of their outcome, and not in terms of their making, this kind of definition avoids confusion and concentrates on their "generative" nature:

> "In order to explain macro-level outcomes, an additional step typically is required: the mechanisms must be assembled into a generative model which allows us to derive the macro-level outcomes they are likely to bring about […] A social mechanism, […] refers to a constellation of entities and activities that are organized such that they regularly bring about a particular type of outcome."
>
> (Hedström and Swedberg, 1998; p. 112)

Major advances in computational and simulation agent-based models of society and social systems have shaped the interest in emergentist models of explanation, which are based on generative mechanisms. Hedström has repetedly explained and illustrated the strong connection between the two approaches on the basis of methodological individualism. He stressed the role structure plays in such approaches, elaborating a new version of methodological individualism, namely the *structural individualism* (Hedström and Swedberg, 1998; Hedström, 2005; Hedström and Bearman, 2009).

Mechanisms are classified in several types by different authors: McAdam, Tarrow and Tilly (2008) identify environmental, cognitive, and relational mechanisms, Hedström and Swedberg classify

[4] Mechanism has been defined by several authors in very different ways: some authors define what mechanisms are, others define the way they work, their making or their outcome, some see them as having explanative properties, others as having generative properties. For discussions and exhaustive lists of definitions, see the works of Mahoney, Gerring and Gambetta.

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mechanisms in complex, mediating, and theoretical building blocks (Leuridan, 2012). Described as either a "mechanical engine" or as a process itself, the 'mechanisms' have been associated with the dynamic capabilities of agents, and are usually meant to represent these capabilities in an operational effective way in simulation models. In spite of diverse and multiple ways of defining it, the notion is still confusing, since no author provides a clear and complete idea.

For this reason, our approach on mechanism in the present model avoids the 'mechanistic' type of definition, and prefers the 'emergentist' one. The *generative mechanism* in our approach is an abstract model of processes unfolding, whose proper workings can-, but whose outcome cannot be described in terms of its inputs. It is rather a tentative operational description of what a mechanism is supposed to do in an agent-based generative setting.

In agent-based systems, mechanisms are usually regarded as basic elements which make a generative structure operational, and include pre-defined aspects either as combinations of contextual conditions and agents' interaction capabilities or as "black-boxes" (Boudon, 1998).

In this paper, we address two types of operational descriptions of mechanisms. The first is the usual one in social simulations, namely a condition-based or context-based evaluator & triggering engine. The second one is used by the emergentist modeling paradigm in complex adaptive systems, where a mechanisms is sometimes operationaly described as a set of processes which converge to a shared, global outcome (Cederman, 1997, 2003a).

4.2 Processes

In our model, we base our abstract architectural concept on the notion of *process* as it has been associated to generative models by sociological generative process theorists (Fararo, 1989), by theories of social forms of Simmelian inspiration (Cederman, 2003a) and in the agent-based modeling literature (Emirbayer, 1997). The notion of process in our approach combines the perspective of political process (Tilly, 1995, p. 1595) with the perspective of generative modeling (Schelling, 1978; Axelrod, 1995, 1996, 1997; Casti, 1997; Epstein and Axtell, 1996; Epstein, 1999).

In generative modeling, political phenomena should be explained by constructing generative processes as artificial counterpart of the real ones. Artificial generative processes become effective in contexts which are themselves artificial replications of real contexts. The idea of describing a process by actually generating and running it as a simulation has been introduced by Axelrod (1995) and also by Epstein and Axtell (1996) and it has been ever since considered as the basic principle in Social Simulation.

Following the description of Fararo (2000) we use the concept of generative process as a computational run of an operational construction whose behavior manifold reproduces a relational pattern by means of "*recursively iterated operations*" (Cerderman, 2003a) of simpler (lower-level) processes, which we agree to identify as rules or mechanisms. This operational definition provides for modeling processes as either variational structure-dependent or structure-emergent outcomes. As Fararo (*ibid*.) defines it, a process is the emergent phenomena associated to structural variation. The basic idea in using generative processes as recurrent outcomes of computational runnings of recursively iterated operations is to reproduce by means of simulation the recurrent patterns of political phenomena.

The notion of recurrence has been employed by different social process theorists (Giddens 1979, p.5; 1989, p.252; Tilly, 2000, p.3; Fararo, 2000) as a generative principle of macro-level emergent phenomena. In our artificial polity model architecture, the notion of 'recurrence' addresses both the patterns of historical phenomena and the principles of their generative modeling.

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The typical operational layer in this architecture combines the idea of continuum[5] with the concepts of 'cross-recurrent' and 'cross-recursive' processes[6], terms used in our approach to describe political processes with simultaneously or asynchronoulsy recurrence (Tilly, 1995) and political processes whose evolution is strongly influenced by their history and also by the history of other co-existing recursive processes. The operational structure consists in a set of processes, described as generative nodes in **Figure 2**. Each process is defined recursively and its operational description might include as inputs other processes defined recursively themselves.

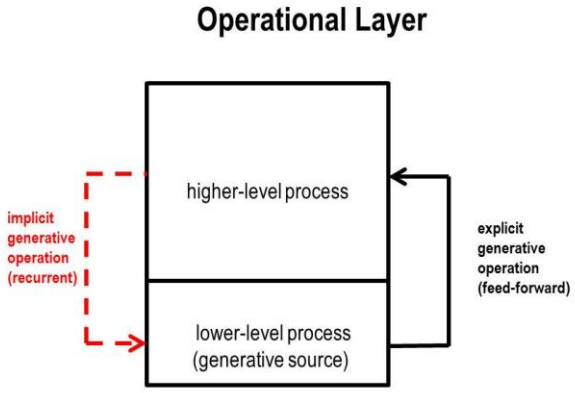

Figure 2.

In this case, we can describe the typical generative structure as a set of cross-recurrent cross-recursive processes as depicted in **Figure 3**. In the simulation experiments we use a set of cross-recurrent cross-recursive processes describing the political attitude change in individual agents. The recurrence of process ***i*** depends on the recurrence of process ***j*** and each process is dependent on both its own history and on the history of the other process. (Voinea, 2012, pp. 130-135; 2013, pp. 104-106).

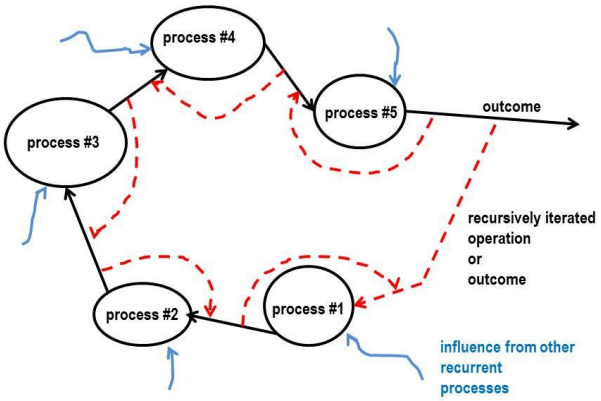

Figure 3.

[5] See (Voinea, 2013) for more details on the concept of continuum in political culture theory and in our approach in particular.
[6] For an extensive discussion on the notion of 'recursivity' in social and political sciences, see Voinea, 2013; Note ? p. ??)

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Recurrence is defined for all types of agents (political culture agents, individual agents, societal agents, institutions, etc.) for all layers in the operational architecture. This makes the operational architecture work as a continuum of generative processes – an operational idea which is meant to support the three continua description of the artificial polity conceptual model (Voinea, 2013; pp.106-107). This architecture allows for the approach of political processes as context-dependent, and path-dependent processes. It thus makes possible to achieve complex conditions defined by the "*increasing returns*" (Pierson, 2000) and the dynamically recurrence of complex conditions in structures of generative processes.

4.3 Pathways

Addressing the issue of political change, Tilly's view was that the explanation of political change phenomena should be based on mechanisms and processes which, if properly chained, could provide for real causal chains or "*pathways*" (Tilly, 2001). Introduced as an explanative concept, the *pathway* has been for some time the theoretical icon of explanative causal chains of political processes (Friederichs, 2013).

In our modeling approach, the *pathway* concept gets a new interpretation and a new operational support. The *pathway* is defined as an activation path in a lattice of processes interconnected by means of shared political culture agents (i.e. beliefs, values, norms and attitudes). Its effectiveness resides in the capacity of the activation network to chain active processes on an cross-reference basis, by identifying shared activation context and/or constraints. The idea is not completely new for areas like semantic networks or coupled lattices, but its use in a political culture-based simulation model of a polity is new. The *pathway* could thus be considered and described as a phenomenon emerging from multiple interconnected (cross-recurrent cross-recursive) processes characterized by different levels of activation.

In this approach, the pathway appears as a emergent and thus gets a considerable explanative power in much the same way in which this has been claimed by Tilly: it shows how processes describing political phenomena chain to one another on the basis of a generative principle of activation and provide therefore for a global outcome.

5. A Political Culture-Based Simulation Model

There are several classes of generative mechanisms, which could be classified on several criteria. We only address in our approach two such criteria: (1) the level of generated (emergent) patterns (micro level, macro level), and (2) the nature of generated (emergent) patterns, such as interaction, structure, interconnection, and control patterns.

Following the criterion of the level of generated interaction, the generative mechanisms classify in two classes : (i) a class of generative mechanism at the level of micro (individual) agents, and (ii) another class of generative mechanisms at the level of macro agents. We include here generative mechanisms for micro-to-macro and macro-to-micro emergent phenomena.

Following the criterion of the type of generative capacity, there are three classes: (i) interaction generative, (ii) structure generative, and (iii) control generative mechanisms.

Our simulation model of artificial polity has been tested in three simulation scenarios: (1) the emergence of corruption as macro-level phenomena (*briberyscape* model), (2) the emergence of networks of trust (privilege networks) generated by the change in the political attitude of the individual agents toward the state (privilegescape model), and (3) the emergence of patron-clients networks generated by the dynamical decreasing levels of trust in political institutions (baronscape model) (Voinea, 2012).

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The model employs three types of agents: (1) individual agents (micro-level agents), (2) aggregate agents (macro-level agents), like institutions, statal political actors, non-statal political actors, etc., and (3) culture agents, like values, norms, beliefs, and attitudes. The micro-level and macro-level types of agents are employed on the corresponding architectural layers only. Political Culture agents (vaues, norms and beliefs) can be employed at any architectural layer in the simulation model, since both micro-, and macro-level agents interact with (political) culture agents.

At the micro level, the individual agents (citizens) interact with the (political) culture agents (values, norms, beliefs, attitudes). Their interactions may result in (upward) relationships characterized by an intensity attribute, which model how much an individual agent "holds" a belief, "appreciate" a value or "comply with" a norm. These relationships could result from socialization processes, or other cultural/ideological networking processes which involve both individual agents and culture agents: the connections in these networks are dynamic, expressing strong/weak (with various degrees) relationships.

At the macro level, aggregate agents, like institutions, interact with the (political) culture agents (values, norms, beliefs, attitudes). Their interations may result in (downward) relationships influencing behaviors of micro-level individual agents.

5.1 Political Culture Modeling and the "Thick-and-Thin" Continua

The *micro-to-macro link* (emergence or upward causation) employs the "thick-to-thin" direction on the political culture continuum (Voinea, 2013; p. 92). Emergence of macro-level phenomena as outcomes of individual interactions are coupled with processes of political culture dynamics. As new networks of trust emerge and co-exist, the individual agent escapes the network of trust in state and joins private networks (the so-called "networks of privileges" in (Voinea, 2012)). As the sizes of private networks of trust grow, they insulate the network of trust in state. This results in emergence of change in political attitude towards the state.

The *macro-to-micro link* (downward causation) employs the "thin-to-thick" direction on the political culture continuum (see once again Voinea, 2013; p.92), in which the macro-level phenomena become effective on a political culture dimension, and this influence points downward to the micro level. The effect can be described as a shift in individual value preferences towards basic values, and an ever decreasing level of individual trust in state (micro level). In turn, these micro-level effect would further result in the change in the individual political attitudes toward the regime, and ultimately in the emergence of political regime change (macro-level). An example taken from the experimental scenarios simulated with our model is the political change in 1989 in the Eastern European countries. In general terms, it can be described as follows: the social and political constraints imposed by an extremely centralized economy and a highly coercive authoritarian regime resulted in a shift of public preferences toward basic values along with an ever decreasing level of individual trust in state. As the ideological institutions of the communist regime forced each individual to claim and prove a high level of trust in state, a difference appeared as the individuals internalized or not the ideological requirement for compliance. As the time passed, this difference has been sharpened by the day-to-day living, which has finally induced a high level of cognitive dissonance at the individual level. It allowed for the emergence of change in the individual political attitudes toward the regime and, ultimately, in political regime change (Voinea, 2012).

In our model, we aim to prove that "downward causation" comes true and proves effective on a political culture dimension: the *change in the "thin" aspects* of political culture (attitudes and beliefs) associated to the emergent macro-level phenomena (corruption, emergence of patron-client networks of trust) induces a *change in the "thick" aspects* of political culture at the individual level (micro-level). It is this

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way that we could explain the patterns in the individual value preferences in Eastern European communist and post-communist countries: basic (materialist) values are preferred with respect to self-expression (post-materialist) values. This idea has been suggested by the preliminary results of an ongoing research project concerning political socialization[7]. The project develops analysis of Post-materialist index (4-item) with WVS[8] survey data in the Eastern European countries during the communist and post-communist regimes from 1981 to 2014 (see **Appendix 1**). This analysis suggests that Eastern European communist regimes were characterized by large public preference for basic values. According to the very few empirical data available from the Eastern European countries where this survey has been developed before 1989, this kind of preference has been preserved in the population even after 1989, notwithstanding major political regime change in Eastern Europe (see, for example, Hungary as showed by the post-materialist index (4-item) in the WVS data in the waves from 1981 to 2014). In these countries, the low variability in materialist value preferences is relatively stable over large time intervals between 1981 and 2014, regardless the high variability in the economic, social and politic conditions. The survey data is analysed in order to identify the relationship between the dynamics of political attitude change and the unusual stable and extremely high level of preference for basic materialist values in spite of major political change phenomena initiated in 1989. Though very much inspiring and related to the present approach, this subject will be further developed as a distinct approach (Voinea, 2014, *forthcoming paper*). In the present paper, we limit the approach on Eastern European polity and political change simulation to the hypothesis that the emergence of macro-level political phenomena (like, for example, emergence of patron-client networks of trust in Eastern European communist countries) has a strong modifying effect on the individual behaviors at the micro-level, and of the individual political attitudes. This effect is produced by means of a long-term dramatic shift in value preferences of the major part of the population. This long-term value shift works merely as a process of weakening the (vertical and horizontal) anchors of individual political attitudes (McConnell et al., 1997; Priester and Petty, 1996; Petty and Krossnick, 1995; Wilson and Hodges, 1992; van Deth, 1983; Rajecki, 1982). This dynamic process (see **Appendix 2**) is proved to have unexpected profound axiologic consequences at the individual behavior level. Moreover, modeling the dynamics of anchor dissolution process seems to support the idea that the increasing individual cognitive dissonance level feeds back on the individual value shift process and helps keeping a relative stability in the preference for basic values in a large population as long as the anchors have not been restored, no matter if the political regime changes. This hypotheses is currently tested in several experimental settings and with different techniques of nonlinear dynamics simulation: (a) agent-based simulation system, and (b) complex adaptive system.

This paper reports only preliminary results, which appear to support the hypothesis of anchor dissolution as a means of making effective the downward causation in the polity and political change modeling simulation. Further developments are nonetheless necessary as ongoing research shows.

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[7] Political socialization in Eastern European post-communist countries has been an issue of major research interest during the decades after the Fall of Berlin Wall. The public surveys concerning this subject are very rare and survey data obtained before 1989 from Eastern European countries is very scarce, since such surveys were not allowed during the communist regimes in Eastern Europe. However, WVS succeeded to provide such survey data, which are extremely valuable as empirical support for the research concerning political change and political attitude change in the Eastern Europe communist regimes in 1989. Appendix 1 provides a brief presentation of the working hypotheses and ongoing research developeed by the author on this subject See also a preliminary report in: Voinea, C.F. (2014) Eastern European Political Socialization Modeling Research: A Literature Review, European Quarterly on Political Attitudes and Mentalities (EQPAM) Vol.3 No. 1 January 2014, pp. 43-55.

[8] WVS data and online analysis available online at: http://www.worldvaluessurvey.org/

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5.2 The Simulation Loop

The main simulation loop: an artificial society with citizens (individual agents), resources (environmental agents) and political culture (culture agents), is grown-up (see **Appendix 2** for more details).

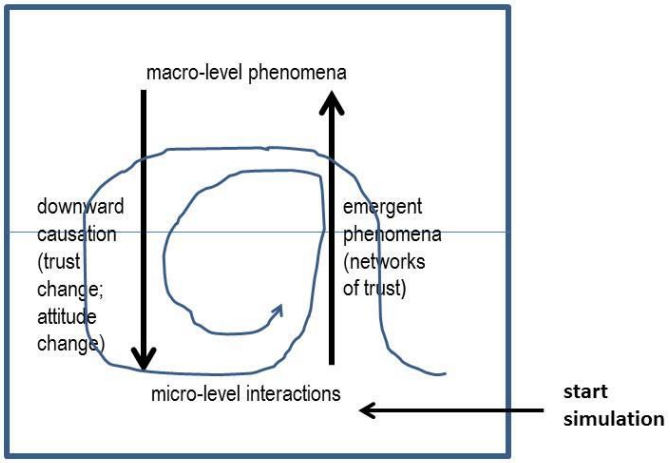

Figure 4.
Simulation Loop.

The experimental setup models a polity by selecting some of the relevant features of (a) authoritarian and (b) democratic regimes. Two main polity models have been constructed: the Communist (CPM) and the Democratic Polity Model (DPM). The Democratic Polity Model has also two variants: the Transition-to-Democracy Polity Model (Ts-DPM) and the Democratic Consolidation Polity Model (Cs-DPM) (Voinea, 2013; p.111).

In our approach the individual agents act always in a norm space, and with permanent reference to a value system: the individual actions and the patterns of collective action always include a relation to the associated value system. Individual agents interact in the dynamic normative and relational context of a particular type of polity, namely the Communist Polity Model (CPM), Democratic Polity Model (DPM) and its variants. For each of them, only some relevant features have been modeled: for the CPM, for example, we have modeled the centralized structure, the inequality of resource distribution, and the co-existence of parallel networks of trust (the ideology-based and the resource-based networks of trust).

Dynamic contexts are created by endowing the different types of agents with different capabilities of interaction: for example, in the CPM model, resources cannot be accessed unless the individual agents accept constraints and obey certain rules of access. Coercive centralized control of resources is thus achieved as an emergent outcome of individual interaction typology. As individual agents interact in the context of coercive centralized control, two outcome emerge simultaneously: on the one hand, macro-level

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phenomena emerge, like the new networks of trust. On the other hand, individual agents' political attitudes change as an effect of the macro-level emergent phenomena. All this results in modified individual behavior characterized by high levels of cognitive dissonance (Voinea, 2012, 2013).

The simulation scenarios are based on few number of mechanisms and processes. There have been developed several simulation scenarios for the study of emergent phenomena and their downward causation effects at the level of individual behavior. As a reference, the simulated political mechanisms and processes have been identified in Tilly's diagram of political mechansims-based democratization (Tilly, 2001; p.32: Figure1) and selected from *Table1* in same work (Tilly, 2001; p.34: Table1).

5.3 Three Political Culture-Based Simulation Models of Political Attitude Change

Briberyscape is a model of corruption emergence in Eastern European communist regimes. It starts from the hypothesis that the emergence of networks of trust is triggered by a set of interdependent mechanisms such as the inequality of distribution, centralized and coercive control of the individuals' access to resources, scarce resources and the existence of privileges of access[9]. Behavior of an individual agents is defined as a process whose dynamics is dependent of the dynamics of its (level of) cognitive dissonance: as the cognitive disonance increases, the level of trust in state decreases and the individual agent escapes the current networks of trust in state and joins parallel patron-client local network(s) of trust.

Privilegescape is a model of the emergence of patron-client networs as a macro-level phenomenon in an experimental simulation of cognitive dissonance reduction of the individual agents (citizens) with direct impact on their trust in state. It models the emergence of the so-called "privilege markets". The model suggests a scenario of trust variability which is based on value change dynamics. The privilege market, (macro-level emergent phenomenon), influences the change of attitude of the individual agent toward the state micro-level).

Baronscape is a model of emergence of networks of trust which insulate the official institutions and their associate networks of trust. It models the emergence of networks of trust as networks of local corrupt elites concentrating wealth and power. The dominance of corrupt elites in the parochial domains provides the premisses for insulating the central authority and the emergence of parallel networks of trust: while official networks are networks of trust in state the local networks are networks of trust in the local baron, which becomes the true authority of the local domain (county). Emergence of local patron-client networks (macro level phenomena) influences the behavior of individual agents. The attitude of individual agents toward the state changes as the newly emerged networks of trust co-evolve and attract more individual agents. Individual agents escape network of trust in state and join private networks of trust (patron-client networks or "baron networks").

6. Concluding Discussion

Our present *artificial polity model* is aimed at modeling the downward causative power and effectiveness of macro level phenomena.

We aim at elaborating a political culture model of polity which can give an account of both emergence and downward causation phenomena. Such model needs however defining approaches on the concepts of mechanism, process and political culture. The process-generalized view seems to fit better the artificial polity modeling. Moreover, employing political culture theories in polity modeling and simulation

[9] See (Precupeţu, 2008) for a study of the political culture and values in the communist regimes.

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needs a more comprehensive approach on mechanisms and processes, since their definitions are still open to debate.

The concept of *agent* in our approach must meet the requirements of agent-based system able to model both micro- and macro-level phenomena, as well as micro-to-macro and macro-to-micro phenomena. Such systems might involve a specific type of interaction unit: the *process*.

We assume a more important role for the relational dynamics in the artificial polity. In agent-based systems, social behavioral patterns arise as direct outcomes of agent interactions. However, it is not only *interaction* which makes social behavior patterns to emerge, but often the dynamics of the *relationship* between 'individual agents' and 'culture agents', namely values, beliefs, norms, attitudes, symbols, rituals, etc. Relationships of this kind can vary as a consequence of dynamic normative, belief or attitude changes.

For example, in the communist regimes, individual trust in the state decreases over a long time interval. The autonomous patron-client networks of trust emerge as the trust in state decreases, but all this happen at a large temporal scale. This process concerns values change: the individual agent changes the degree in which he or she values something (Archer, 1996). Level of trust in state in the Eastern European communist regimes took almost half-century to decrease up to the bottom because the process of values change was rather slow. This process took very long time, so that we cannot identify it with the direct outcome of an interaction mechanism. The other way around is also true: the level of trust in state in post-communist regimes has not increased in more than twenty years after the Fall of Berlin Wall, because individual agents are very slow in changing the materialist value system (Inglehart, 1997, 2000; Inglehart and Welzel, 2005). Therefore, patterns of trust cannot be identified with patterns of direct interaction between the agent and the state. Their emergence should be directly connected to the patterns of relationships (or rather to the degree of intensity of such relationships) between the individual agent and a political culture which guides the interactions and which vary itself as significantly as to be considered as the very source of trust variability. Therefore, a political mechanism which could explain the variability of trust needs at least two levels of description: one is the level of direct agent interactions, the other one is the level of relationship between agent and a political culture. Relational patterns vary much more than individual interaction patterns actually do. Nevertheless, agent-political culture relationships and the relational variability provide the sources for the attitude and behavioral variability.

This view, inspired by the Weberian concept of "value-directed action" and adopted by the political culture-based modeling research, seems much more appropriate to explain how a particular political mechanism and process work in a polity.

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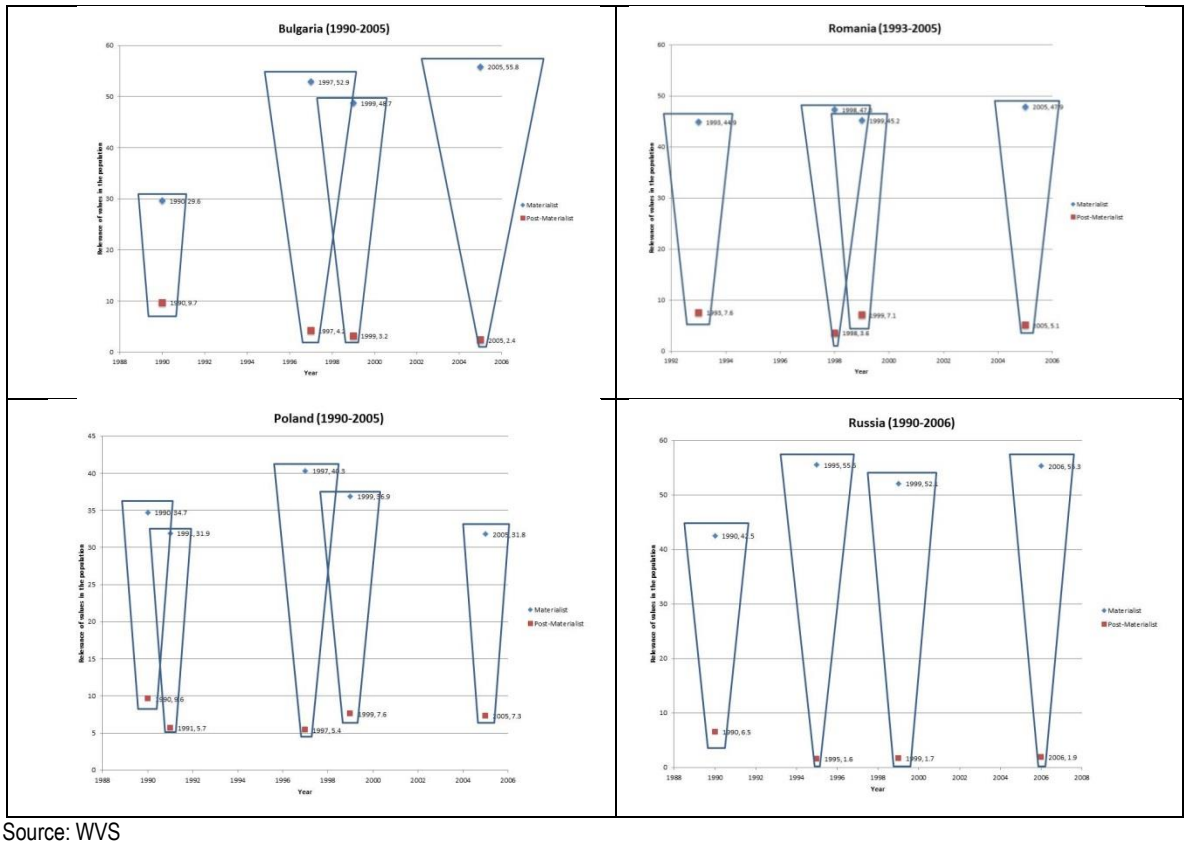
APPENDIX 1

The analysis of the WVS survey data is based on the (Y002) *Post-materialist index (4-item)* available from 1981 to 2014 for the European countries.The Eastern European former communist country for which the survey data is reported for a period before 1989 is Hungary only. For some other Eastern European post-communist countries, the survey data is reported only after 1990, and a number of these countries have been selected for a comparative analysis: Bulgaria, Romania, Poland, and Russia. For the Western European countries, the survey data is reported both before and after 1990, and allows for comparisons with the Eastern European former communist countries. The selected countries from this class are: Belgium, France, and Finland.

The examples of Bulgaria, Romania, Poland, and Russia show a considerable difference between large societal preference for the materialist values and a very narrow population segment which expresses preference for the post-materialist values (**Figure A1-2**). In such countries, the low variability in value preferences is relatively stable over large time intervals between 1993 and 2010, regardless the major variability in the economic and politic conditions.



Source: WVS

Figure A1-2.

Proportions of value preferences [%] for each sample/country/year. Survey data reported for Bulgaria, Poland, Romania, and Russia. (The graphical rectangular shapes are meant to visually highlight the comparative differences between materialist vs. post-materialist value preference proportions in each sample/year/country).

This difference is made evident by the particular case of Hungary (i.e., WVS survey data for post-materialist index (4-item) available from 1982 to 2009): the preferences for materialist values during the communist regime are expressed by a large segment of the population (48.9% in 1982), while the preferences for the post-materialist values are expressed by a very small segment (2.3% in 1982). After two decades (the survey data is reported for 1998 and

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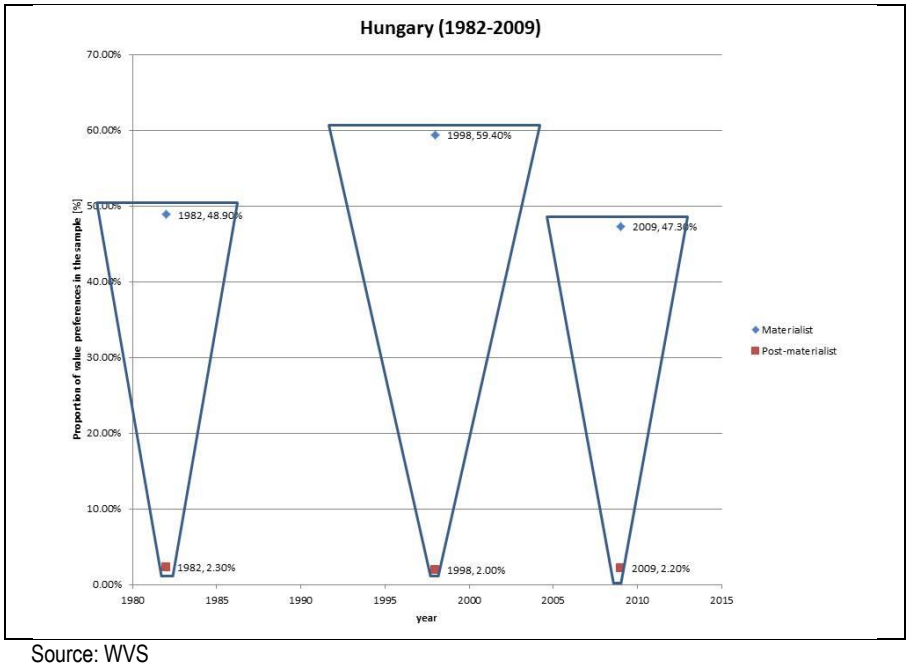
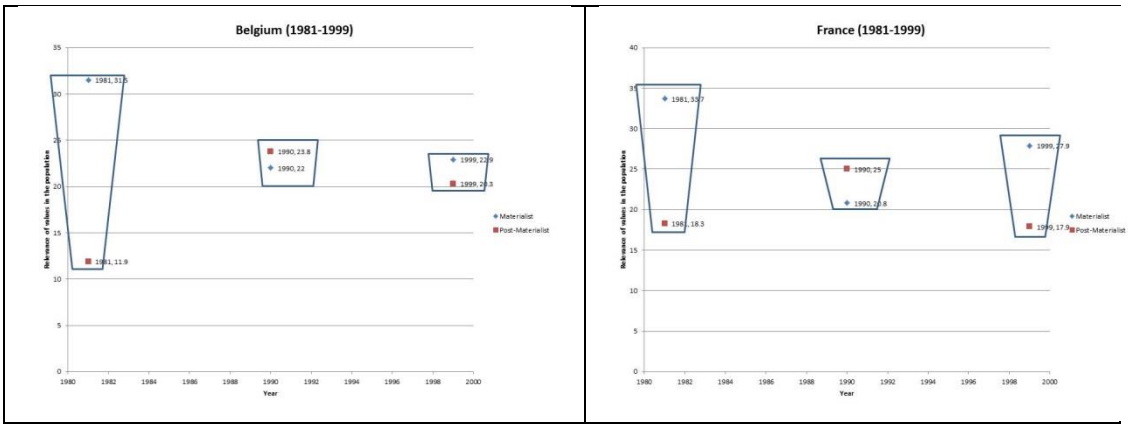
2009), these levels remained stable, notwithstanding the major political and economical changes undergone by the Hungarian regime after 1989 political regime change (**Figure A1-3**).



Source: WVS

Figure A1-3.
Proportions of value preferences [%] for sample/country/year. Survey data reported for Hungary.
(The graphical rectangular shapes are meant to visually highlight the comparative differences between materialist vs. post-materialist value preference proportions in sample/year/country).

As compared to the Eastern European post-communist countries, Western European countries show more variability in their preferences for materialist vs. post-materialist values over shorter time intervals. Moreover, in these countries the preferences could switch between materialist and post-materialist values in close dependence to the economic (crisis) and political conditions (e.g., elections outcomes). The examples in **Figure A1-4** show the preferences in Belgium, France, and Finland, respectively.



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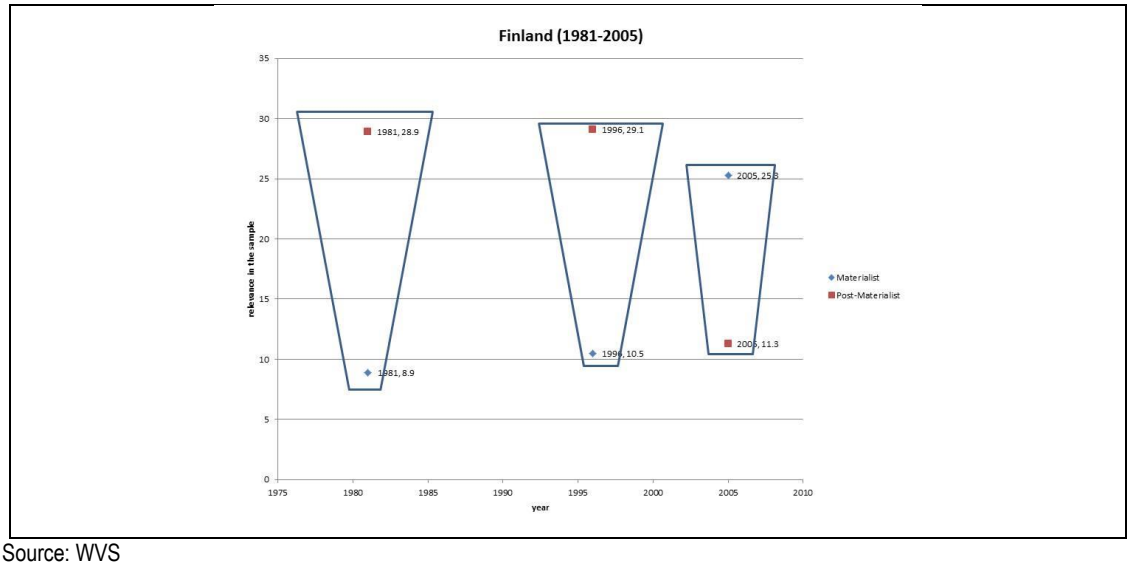

Source: WVS

Figure A1-4.
Proportions of value preferences [%] for sample/country/year. Survey data reported for Belgium,France, and Finland.
(The graphical rectangular shapes are meant to visually highlight the comparative differences between materialist vs. post-materialist value preference proportions in sample/year/country).

A simple comparison between value preferences expressed in the survey samples (%) allows for the identification of specific patterns of variability/stability in the level of these preferences for the selected countries. For an easier identification of the variability patterns, a geometric representation is suggested such that for each country/sample/year the comparison is made visible by rectangular shapes. These rectangles are aligned on a system of parallel axes: the higher axis stands for the post-materialist values preference in the sample (%), while the lower axis stands for the materialist values preference in the sample (%). The geometric representation is based on a length comparisons of the rectangles edges: the higher edge (post-materialist value preference) is graphically compared to the lower edge (materialist value preference), like in the figure below:

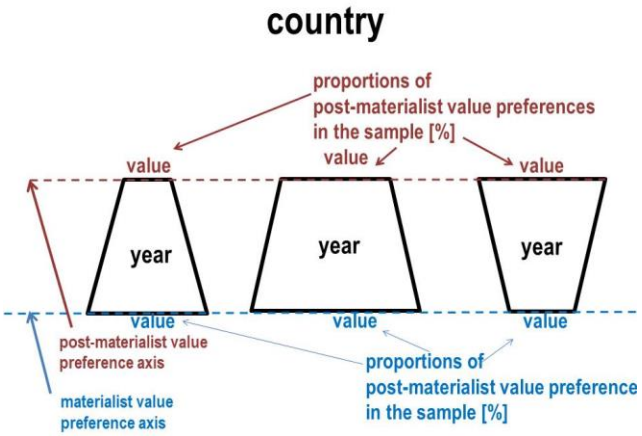

Figure A1-5.
The geometric representation of value preference patterns.

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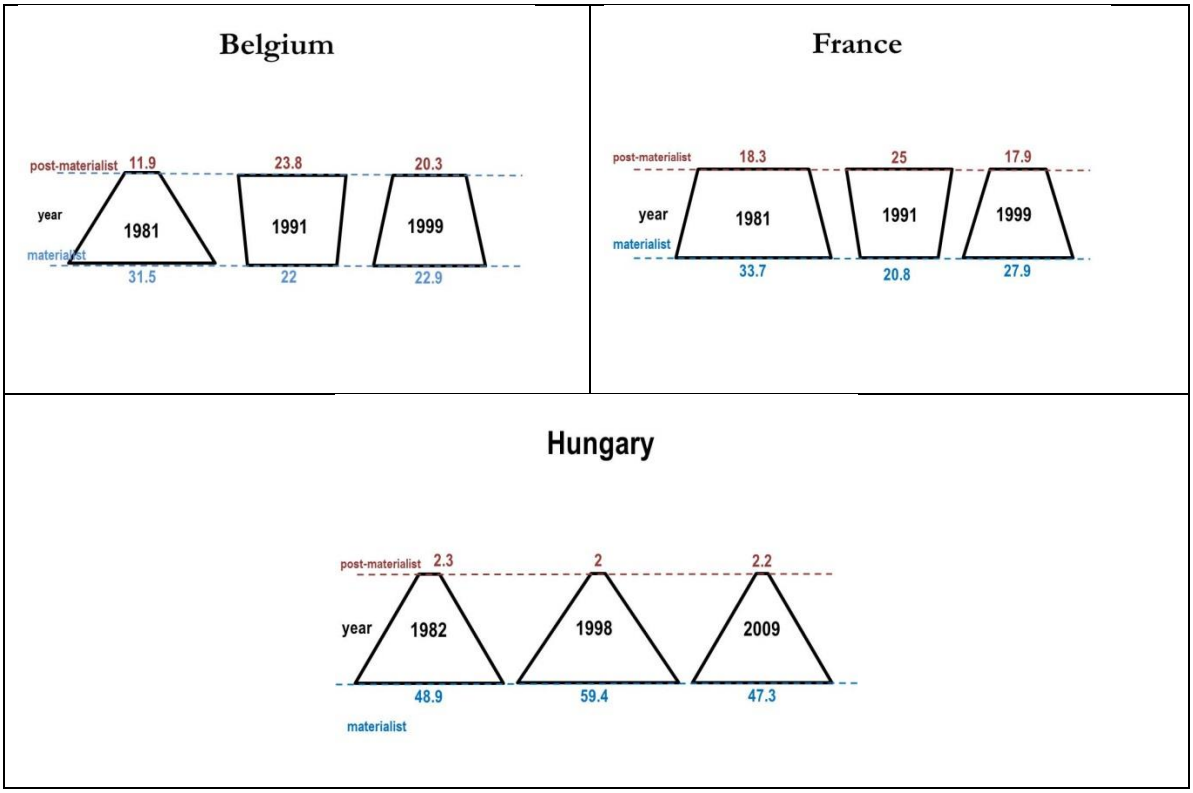
The geometric representation helps identifying specific patterns of variability/stability in individual value preferences as observed in empirical data. In the Eastern European former communist countries a stability pattern is identified in the high level of preferences for materialist values both before and after 1989 in spite of dramatic political regime change and economic market change (Hungary). For the same period of time (largely, between 1981-2014), in the Western European traditional democratic countries, like Belgium and France, a (high) variability pattern is identified which consists in alternate preferences going from quite similar proportions to eventually completely reversed proportions of preferences in the same society during short time intervals (one decade and, sometimes, even less) (see **Figure A1-6**)[10].



Source: WVS

Figure A1-6.

Patterns of high variability in value preferences in some of the Western European democracies (see the examples of Belgium and France), and patterns of high stability in value preferences in some of the Eastern European former communist countries (see the example of Hungary), for the same interval of time: 1981-2010 (Source: WVS).

The preliminary results of this empirical study provide support to the ideea that downward causation works and could be proved as effective on a political cultural dimension of a polity simulation model as explained in *Section 5.1* of the present paper. Modeling the preferences for materialist vs. post-materialist value in different societies and political regimes provides support to the idea that political culture modeling explains the macro-to-micro (downward causation) phenomena: changes in macro political conditions (for example, the political regime change from communism to democracy in Eastern Europe in 1989) induce changes in individual value preferences (materialist vs. post-materialist values), which result in further changes in the individual behaviors and attitudes toward state/govern.

[10] This empirical study is part of a political socialization research project currently developed by the author.

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APPENDIX 2

Processes

In the agent-based simulation experiments we use a set of cross-recurrent cross-recursive processes describing the political attitude change in individual agents (Voinea, 2012, pp. 130-135; 2013, pp. 104-105). The recurrence of one process, *i,* depends on the recurrence of another process, *j*, and each process is dependent on both its own history and on the history of the other process.

At any moment of time t, $process_i$ is described with a logistic function. Its outcome is adjusted by the effect of a cross-recurrent $process_j$ (Zbilut and Webber Jr., 1992; Webber Jr. and Zbilut, 1998; Webber jr. and Zbilut, 2005; Burykin and Adamcsek, 2005). The cross-recurrent cross-recursive processes in our simulation models are: "*political-attitude-change"*; "*trust-in-state", "individual-responsibility* (towards state, family and self), *fairness* (in relations with other citizens and with the state), and *honesty* (in personal relations amongst individual citizens).

Cross-recursivity is used as an unidimensional dependence relation between two processes only. We have limited the description for the sake of simplicity so as to be able to express in an operationally efficient way the idea of cross-recurrence, cross-recursive processes. This allows us to express simple relationships between several processes in generative terms as follows: the individual agent develops a *political attitude* toward the state, which depends on the agent holding a certain belief (*trust-in-state*), appreciating a certain value (*honesty*), and complying (*fairness*) with the norms of centralized access to resources (coercive rules, as described in Voinea (2012)). As the difference between agent's personal needs (in terms of personal resources) and what the state offers (i.e., constrained access to public resources) increases, the agent's cognitive dissonance level increases as well, which has a negative impact on the individual agent's trust in state and, therefore, on her attitude toward the state. This circular dynamics makes the downward causation efective: the emergent macro phenomena, that is the emergence of new networks of trust and agents migration from one network to another have an explicit and quantifiable influence on the individual behavior (see Privilege Market simulation model in (Voinea, 2012)).

Artificial Polity Simulation Models

The agent-based simulation system has been developed in NetLogo (**Figure A2-1**). The interface consists in individual agents, resource (environmental) agents, and political culture agents. An artificial society with citizens (individual agents), resources (environmental agents) and political culture (culture agents) is grown-up. Model structure includes several types of individual agents (citizens, bureaucrats, magistrats, and politicians), several types of resources (financial, economic and institutional), and a value system, which includes individual values ("honesty", "fairness"), and individual beliefs ("trust-in-state"). The processes on which the "downward causation" idea is based and which makes it effective are the "responsibility" and the "trust_in_state": in the context of a CPM model, a shift in the individual values operates by decreasing the individual levels of "honesty" and "fairness". The cognitive dissonance mechanism is achieved as two other processes, "responsibility" and "trust_in_state", recursively update the difference between the individual values ("honesty" and "fairness"). The detailed description of agents and processes can be found in (Voinea, 2012).

The system is run over long simulation time intervals: one simulation run covers the equivalent of 10 years in time units which represent "months". One complete simulation covers 50 years time. Some experiments have included simulations for 100 years.

The experiments have been developed in the corruption simulation modeling project andd include three types of polity simulation models: *briberyscape, privilegescape*, and *baronscape* (Voinea, 2012). This **Appendix** illustrates the *privilegescape* simulations, which are described bellow. Downward causation is proved by means of the dynamics of change in cognitive dissonance levels of individual agents.

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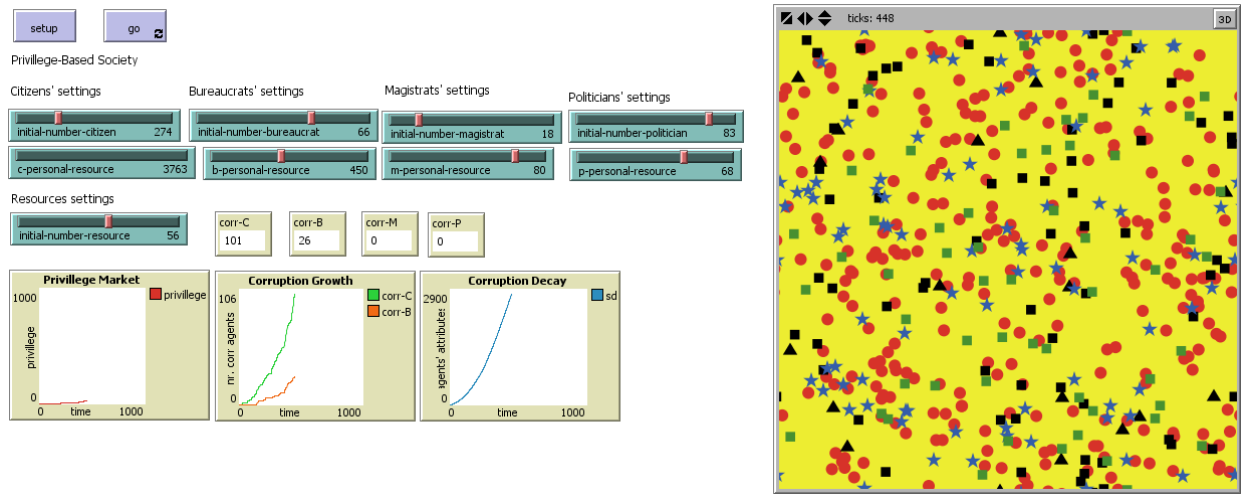

Figure A2-1.
The NetLogo interface of the simulation system.

Individual agents interact in the dynamic normative and relational context of a particular type of polity, namely the Communist Polity Model (CPM) (see **Table 1**).

Table 1. The Simulated Political Mechanisms in the Artificial Polity Model

Simulation Scenario(s) / Political Mechanisms	Networks of Trust	Inequality
Authoritarian Polity Model (CPM)	a.Generalized network of trust; included in polity; b.Coercive centralized control and the macro-level emergence of parallel autonomous networks of trust (patro-client networks)	a.Coercive control of the access to resources enables relations of exploitation b. Generalized categorial inequalities in public politics
Democratic Polity Model (DPM)	a.Insulation of existing categorical inequalities from public politics b. Incorporation and expansion of existing trust networks into the polity	a.Dissolution of coercive controls supporting current relations of exploitation b. Insulation of existing categorical inequalities

Political Attitude Change

The experimental setup models the emergence of patron-client networks of trust as a macro-level phenomenon in an experimental simulation of cognitive dissonance reduction of the individual agents (citizens) with direct impact on their trust in state. The experiment simulates the emergence of the so-caled "privilege markets" in a CPM modeling framework (**Figure A2-2**).

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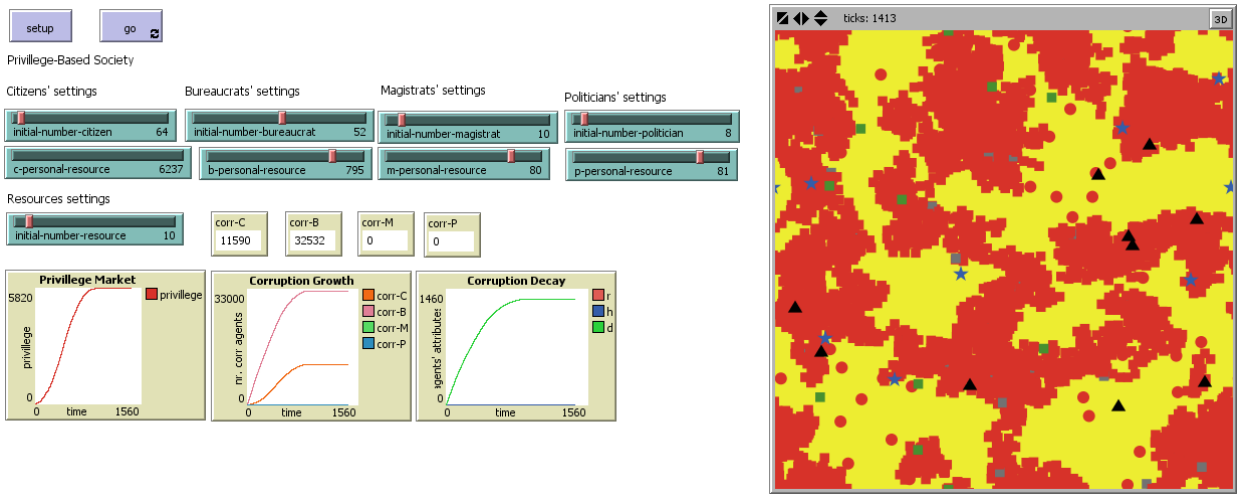

Figure A2-2.

The *privilegescape* simulation model of corruption suggests a scenario of trust variability which is based on value change dynamics (**Figure A2-3**).

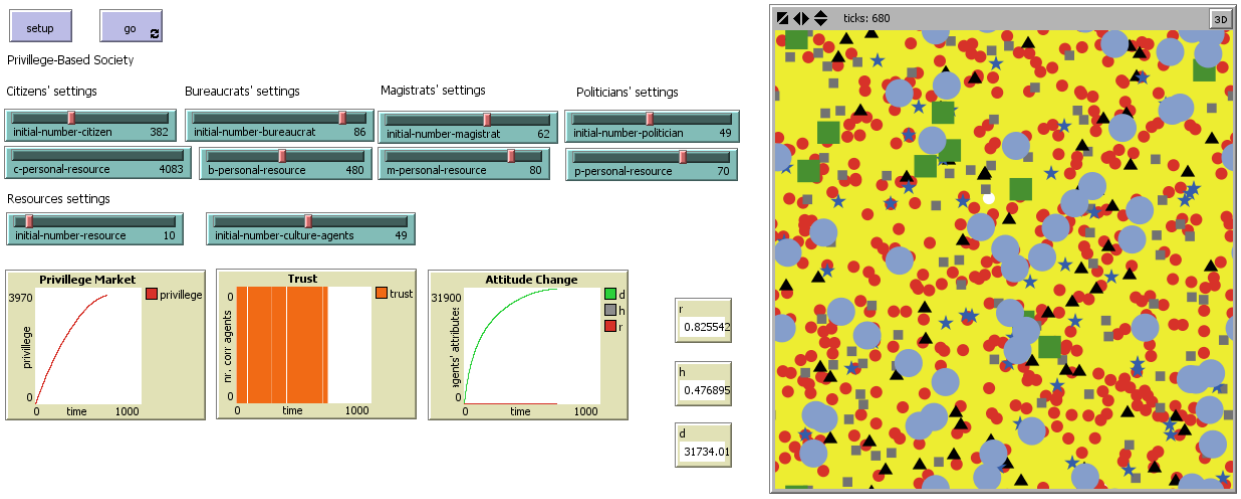

Figure A2-3.

Downward Causation: the "privilege market" (macro-level emergent phenomenon) influences the political attitude of the individual agent toward the state (micro-level) by means of a long-term shift in individual value levels (political culture dimension). The dynamics of change proved by the process of "responsibility" shows that for increasing levels of "cognitive_dissonance", the individual agent proves an ever decreasing level of "trust_in_state" (**Figure A2-4**). The experrimental data has been generated by the agent-based system described above as an artificial society. The NetLogo interface provided online plots of various processes outcomes. Beside the online

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simulation results, the individual process outcomes have been represented separately and analysed by means of Excel diagrams.

In the *privilegescape* model, individual agents obtain access privileges to public resources in order to cover their basic needs (i.e., hunger). The access privileges are "sold" on a "black market" called "privilege market" which emerges at the macro-level of the system as a patron-client network of trust. Dynamics of change in individual values (represented here by means of the "honesty" and "fairness" processes), prove that a macro-level emergent phenomenon, like the emergence of the black market of access privileges, influences the behavior of individual agents at the micro-level (the "downward causation" is simulated on a political culture dimension).

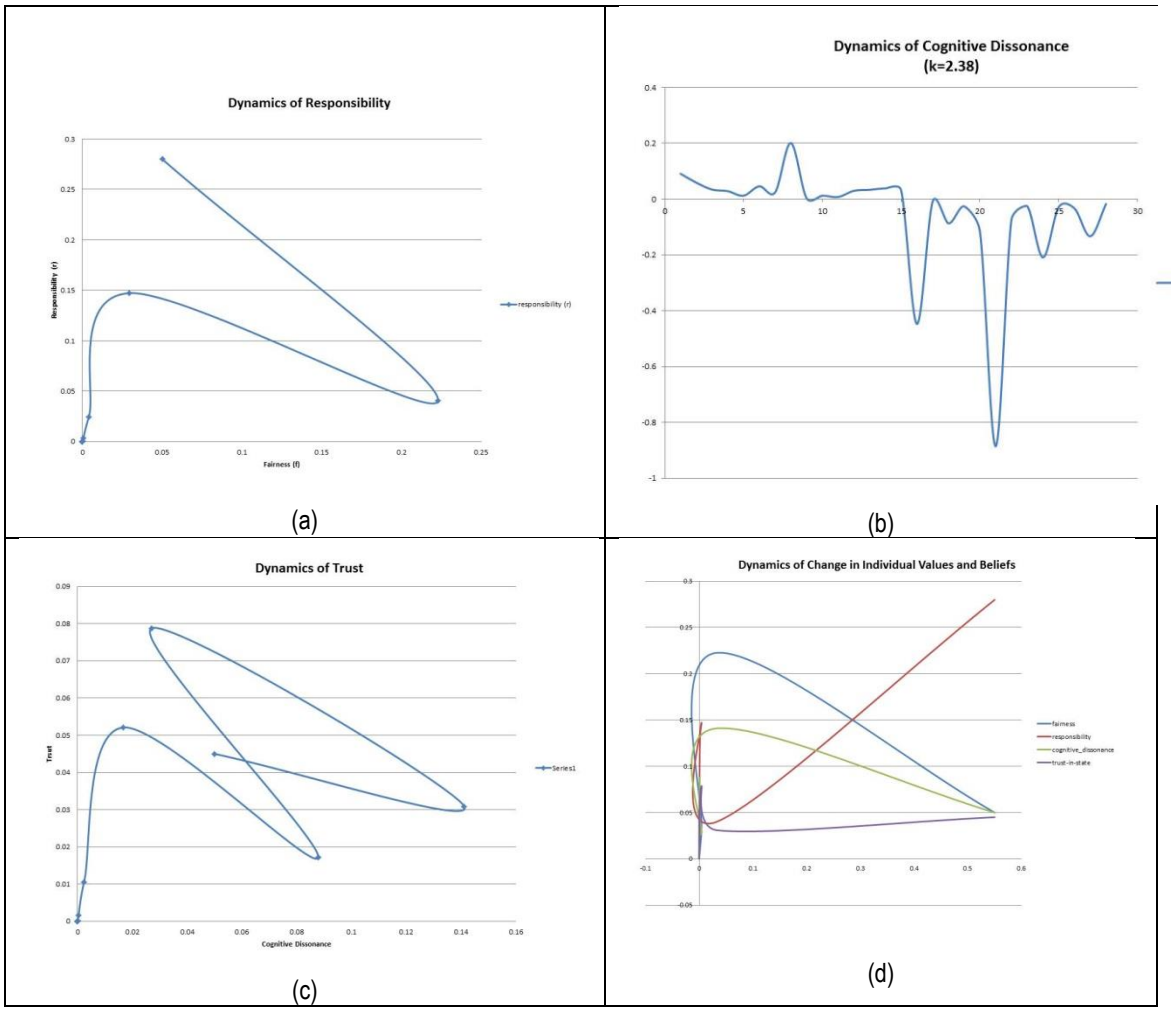

Figure A2-4.

Dynamics of the process outcomes of (a) responsibility, (b) cognitive dissonance, (c) trust in state, and (d) comparative dynamics of change in responsibility, fairness, cognitive dissonance, and trust in state.

The emergence of political attitude change in the *privilegescape* model depends on the cognitive dissonance level: over a certain threshold, the cognitive dissonance level triggers a political attitude change, which in turn allows for the macro-level emergence of political regime change.